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ABSTRACT

The effects of encoding specificity were evaluated for learners: (1) in a typical classroom group learning environment, (2) receiving an audiovisual presentation on an academic subject, and (3) in a group testing environment. Encoding specificity involves the interaction between the encoding phase of memory or the learning context, the stored memory trace, and retrieval cues present at the time of testing for learned information. Traditional encoding specificity studies use a paired associate learning paradigm, process subjects on an individual basis, and use very simplistic learning tasks. The instructional programs used in this study were three slide-tape programs about the parts and operation of the heart (adapted from the Dwyer heart materials), which provided the same to-be-learned target information in the audio portion of the program. Programs varied in the type of cue provided by the slide portion of the program and included: a visual-only slide set containing 37 color visual illustrations with arrows pointing to the part being described; a visual with a verbal label set; and a verbal-only set (no visual information). Testing used either free recall, visually-cued recall, or verbally-cued recall. Test cue type and learning context cues had a significant effect on the ability to perform at the time of testing. Six references are listed. (LMM)

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The Psychological Construct of Encoding Specificity and Its Relationship to Designing Instruction and Tests

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Research Problem

Prior to explaining the research problem addressed by this study, two questions should be considered. The first question that should be considered is, "What is encoding specificity anyway?". The second correlative question is, "Why is encoding specificity of significance to the field of educational technology and its related interest areas?"

Considering the first question, encoding specificity is a psychological construct that involves the interaction between the encoding phase of memory, or the learning context, and the stored memory trace, and retrieval cues present at the time of testing for learned information. In other words, retrieval of a memory trace at the time of testing, can be a direct function of the match between cues given during learning, and cues provided during testing. The more isomorphic learning context cues are with testing context cues, the more likely the probability of successful memory performance. Of course, given a miss-match between these elements, the inverse will occur. The major issue here is that memory of learned information is not simply a function of cognitive or mental factors alone, but is actually influenced by cues given at the time of learning and cues given at the time of testing. Considering the logical progression of the encoding specificity theory, it is possible then to have information learned or stored in memory, but with testing cues too abstract in relation to learning context cues, test performance becomes a function of the type of cue provided, not what was actually learned. In other words, the learner has learned the information, or mastered certain objectives, but performance fails as a function of the test not what material has been mastered by the learner.

The answer to the second question may at this time be obvious. Encoding specificity is an important construct for educational technology, since our primary objective is the design of effective learning environments, and the ability to evaluate the relative success of learning specific objectives. The encoding specificity construct adds an additional consideration to the design of learning environments that is the concern for the match between learning context cues, the stored memory trace, and testing context cues. Care should be taken, however, to not consider the encoding specificity construct as simplistic, or common sense. The counter argument to this notion is the large number of studies done investigating encoding specificity and its complex effects upon memory (Tulving, 1979; Thomson and Tulving, 1970). An additional argument favoring encoding specificity research as an important research topic for educational technology, is the vast number of classroom tests that present mostly verbal information while related instruction may be visually oriented.

Now that the encoding specificity construct has been defined and its importance defended, why have the authors decided to further investigate encoding specificity since so much seems to be known about it already from psychological research. The primary problem in much of the psychological research on encoding specificity is the incongruence between psychological experimental designs and real learning environments typically found in schools and training situations. The traditional encoding specificity

study uses a paired-associate learning paradigm, processes subjects on an individual bases, and uses very simplistic learning tasks (i.e., stimulus-response learning). For example, the study by Tulving and Osler (1968) used the following experimental design. The two encoding, or learning, conditions were: (1) target words plus cue type A, and (2) same target words plus cue type B, these form the paired-associate. The two retrieval conditions were: (1) present retrieval cue type A, get response, and (2) present retrieval cue type B, get response. The Tulving and Osler (1968) experiment resulted in the following percentages of correct recall.

Learning Context	Retrieval-Testing-Context	
	See Cue A	See Cue B
Targets 1...n+A	62%	29%
Targets 1...n+B	33%	62%

While their results clearly showed that even though both learning context groups received and learned the same target words, successful performance was a function of test cue type, not what was originally learned.

The problem with this type of experimental design, which represents the typical encoding specificity study, is that it is far removed from classroom instruction which typically is group learning, with academic content, and group testing. The primary problem addressed by the present study is the highly clinical nature of past encoding specificity research. The present study was designed to evaluate the effects of encoding specificity when learners were in a typical classroom group learning environment, receiving an audiovisual presentation on an academic subject, and in a group testing environment. However, it was important that the basic encoding specificity design of 'target to-be-learned information' and 'varying cue type' remain constant in the present study. In other words, the basic integrity of the encoding specificity design was not changed. To accomplish this the three learning conditions in the present study, presented the same to-be-learned target information, but in different learning contexts, each having different contextual cues. However, the to-be-learned target information was identical in each of the three learning conditions. Similarly, there were three testing conditions, each condition presenting a different set of cues corresponding to the learning context cues. So the basic encoding specificity design is apparent in the present study but, students received their instruction in a classroom group setting, seeing a slide-tape presentation, the instructional content information was a typical type of academic content material, and testing was done in a classroom group setting.

Experimental Design

The present study represents the third in a series of studies done by the authors on the variable of encoding specificity, and its effect upon learning-memory-testing. The first two studies yielded significant results, partially supporting the encoding specificity hypothesis and revealing the significant relationship between the learning context, stored memory information, and the testing context (Canelos, Taylor, Altschuld, 1983; Canelos, Taylor Dwyer, 1984). However, this study is an attempt to refine the pilot study (Canelos, et al., 1983) and follow-up study (Canelos, et al., 1984) by adding an instructional treatment and refining the testing, or cueing conditions. These refinements should yield results that are more generalizable to the classroom instructional situation. Additionally, these refinements should result in the cross-over statistical interactions found in psychological experiments investigating the encoding specificity variable, but within the domain of a classroom learning environment (see hypothesis of interaction, Figure 5). During the AECT-1984 RTD presentation of the follow-up study the discussant, Dr. Lamberski, recommended further experimentation with our research design on encoding specificity. Dr. Lamberski also suggested that educational technology researchers should follow through with their research by conducting a series of experiments on a given variable to refine and make more applicable their conclusions.

The original pilot study partially supported the encoding specificity hypothesis, which states that: retrieval is facilitated if external retrieval cues, given during testing, match a part of what is stored in memory, as a function of the original learning context. While some researchers may claim such a hypothesis is common sense, in the real world of classroom testing, there is often little attempt to match instructional context cues to cues given on the test. Most classroom tests are verbal, but if visuals were a significant part of the instructional/learning context (i.e., medical and engineering instruction) recall will be debilitated. In this case, the learner may have learned the correct fact or concept, but given only verbal cues on the test, cannot effectively respond. The original pilot study used the following experimental design.

		Free Recall	Visually-Cued Recall Test	Verbally-Cued Recall Test
Immediate Test	Visualized Instruction Plus Audio Program			
	Verbalized Instruction Plus Audio Program			
Seven-Day Delay Test	Visualized Instruction Plus Audio Program			
	Verbalized Instruction Plus Audio Program			

Figure 1: Original Pilot Study Design

The pilot resulted in the following disordinal interaction finding partial support for the encoding specificity hypothesis.

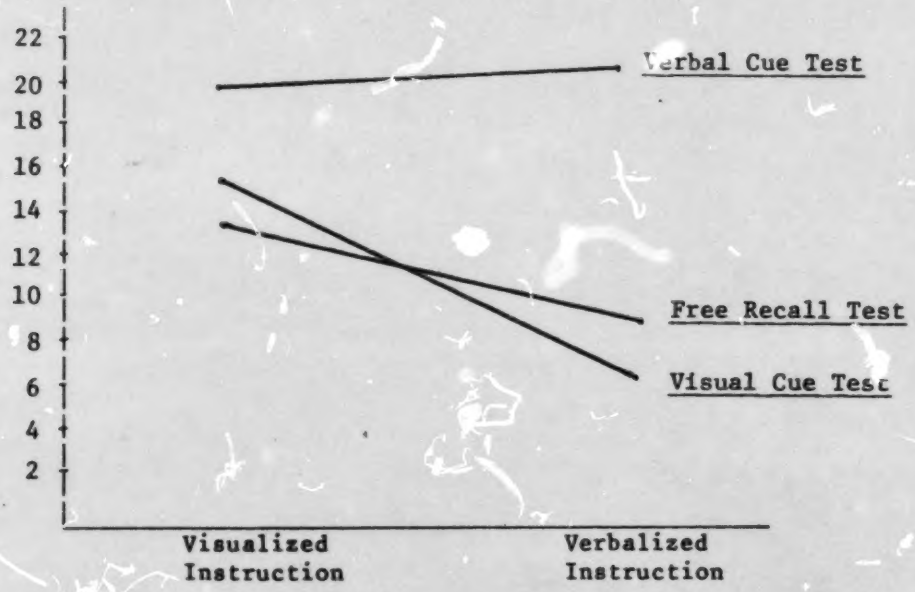

Figure 2: Original Resulting Interactions

However, further analysis revealed that the strong results on the verbal-cue test occurred because the test was operating as a recognition test, rather than a cued recall test. Recognition tasks tend to be easier than free recall and cued recall tasks.

In the second study, the verbally-cued recall test was changed to function as a cued-recall measure. To evaluate this change the second study was conducted using the following experimental design.

		Free Recall	Visually-Cued Recall Test	Verbally-Cued Recall Test
Immediate Test	Visualized Instruction Plus Audio Program			
	Verbalized Instruction Plus Audio Program			

Figure 3: Follow-Up Study Design

This design yielded the following change in the results, and again found partial support for the encoding specificity hypothesis, as indicated by disordinal interaction in Figure 4.

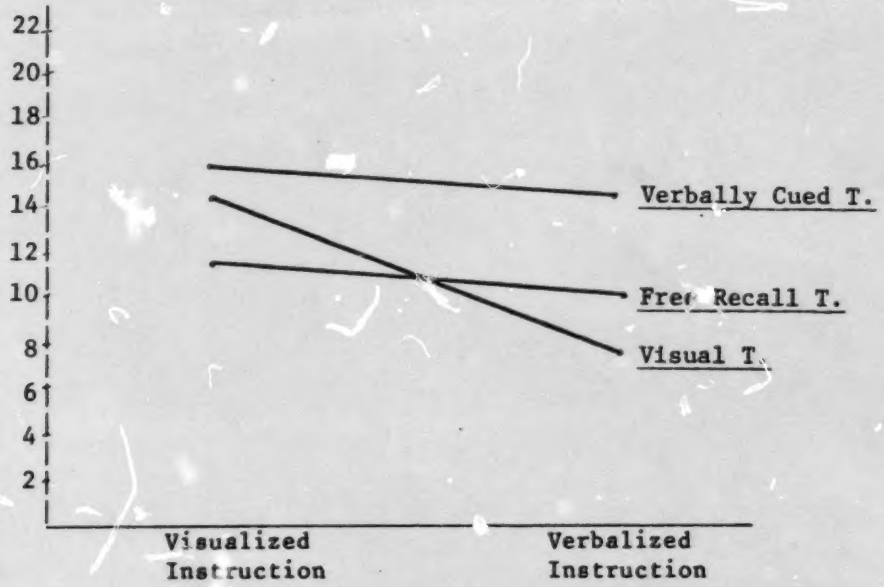

Figure 4: Follow-Up Study Interactions

As can be seen, the verbally-cued test is operating more like a cued recall test than a recognition test. However, the encoding specificity hypothesis would have predicted a cross-over interaction, finding that subjects receiving visualized instruction would do well with visual cues during recall but not verbal cues, resulting in the following hypothetical interaction.

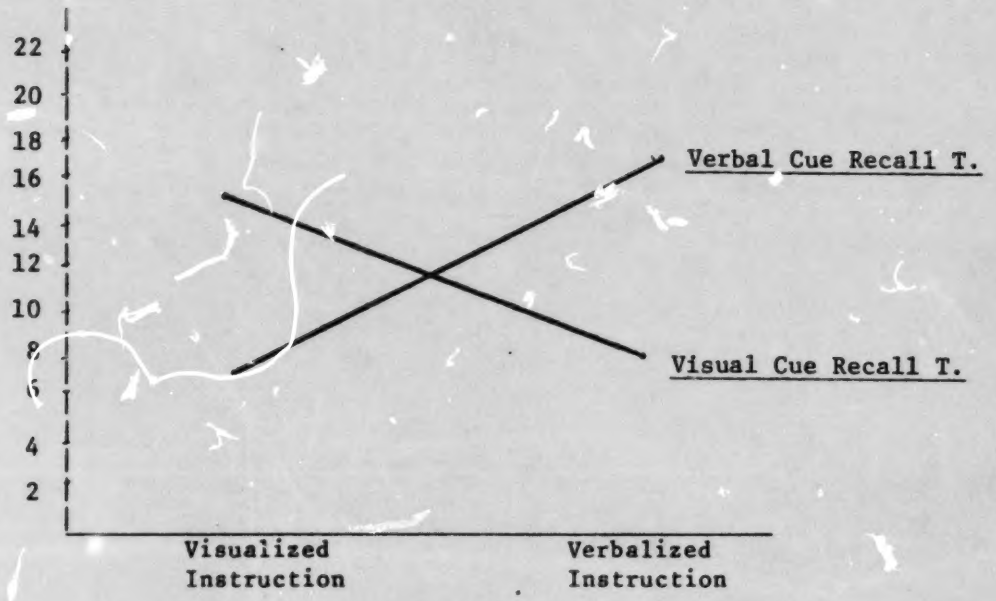

Figure 5: Hypothesized Resulting Cross-Over Interactions

This did not occur in the follow-up study because the visualized instruction group's slide-tape instructional program contained a visual slide with a word label indicating the part name. This label must have been stored in memory along with the visual context on the slide, since the visualized instruction group performed equally well with the visually cued recall and verbally cued recall tests.

The hypothesized interaction, presented in Figure 5, represents the general hypothesis for the present study, which used the experimental design in Figure 6.

		Free Recall Test	Visually-Cued Recall Test	Verbally-Cued Recall Test
Immediate Testing	Visual Only Slide Set Plus Audio Program			
	Visual with Label Slides Plus Audio Program			
	Verbal Label Slides Plus Audio Program			
Seven Day Delayed Testing	Visual Only Slide Set Plus Audio Program			
	Visual with Label Slides Plus Audio Program			
	Verbal Label Slides Plus Audio Program			

Figure 6: Present Study's Experimental Design

The instructional programs were an adaptation of the Dwyer (1967) human heart instructional and testing materials. The instructional materials were adapted to fit the design of an encoding specificity study however, this adaptation did not change the validity of the Dwyer materials as a logical audiovisual instructional program about the parts and operation of the human heart. The Dwyer instructional materials about the human heart consist of an instructional presentation designed to teach the names of the parts of the heart, heart part locations, and the part functions during the blood flow process taking place as the heart operates. The Dwyer instructional program on the human heart has been adapted to a variety of experimental studies, ranging from programmed learning, print materials, and computer based learning. The present study uses the instructional media of a slide-tape audiovisual classroom presentation of the basic Dwyer heart instructional program.

The experimental design is a 2x3x3 Lindquist type-II design. There are two between subjects variables and one within subjects variable. The within subjects variable was time of testing. The two levels of the within subjects variable are immediate testing and seven day delayed testing.

The first between subjects variable was type of instructional program. Each instructional program was a slide tape program about the parts and operation of the heart. Each of the three instructional programs provided

the same to-be-learned target information, which was the names of the parts of the heart, and the heart phase names. This information was provided in the audio portion of the slide tape program, which was from the original Dwyer heart audio script. All three instructional programs used the same audio program tape, having the same heart part/phase description, and same pacing by a synchronized pulse. The difference in the three instructional programs was the type of cue provided by the slide portion of the audiovisual program.

The first level of the instructional program variable was the visual only slide set plus the audio program. The audio program was 22 minutes in length and described the parts of the heart, the part names and locations in detail, and the heart's operation. The first level of the instructional program variable slide set contained 37 color visual illustrations of the heart. Each of the slides contained an arrow, or arrows, pointing to the part being described by the audio program, or the phase or operation being described. The visual only slide set provided only visual cues on each slide.

The second level of the instructional program variable was the visual with verbal label slide set. This instructional program used the same audio program tape but the cues given were quite different than level one. The same 37 color visual illustration slides were used, as in level one, but the slides contained a verbal label describing the part name, operation, or phase, being explained on the audio program.

The third level of the instructional program variable was the verbal only slide set. The same audio program tape was used, but again the cues provided in the learning context were quite different than the level one and two instructional programs. The verbal only instructional program contained 37 slides, each slide presented a heart part name, or names, or phase names, as being described by the audio program. There was no visual information provided on the slides for level three, but the verbal labels were the same as those given in level two. So while, each of the three levels of the instructional program variable provided learners with the to-be-learned target information, heart part names/phase names, this information was provided with different cues given in the learning context. Therefore, while all three groups received the same to-be-learned target information, it is likely that they processed this information in different ways, contingent upon cues given in the learning context.

The second between subjects variable was the type of cue provided during testing. The first level of the test cue variable was the free recall test. As the name implies, in the free recall condition the subjects had to write down the names of the heart parts and phase names from memory. The second level of the test cue variable was the visually-cued recall test. Subjects in this group saw a set of color illustration slides of the heart. Each slide contained an arrow, or arrows, pointing to a heart part, or describing a heart phase. The subject had to write down the correct name of the part or phase that the arrow in the visual illustration slide pointed to. The third level of the test cue variable was the verbally-cued recall test. Subjects in this group saw a set of slides, with each slide containing a three letter cue of a heart

part name or phase name. The three letter cue consisted of the first three letters of a heart part name. For example, for the heart part name Myocardium, the letters Myo would be given on the slide. Each of the testing conditions tested for the same objective -- the attainment or memory of the heart part names or phase names. But each testing condition provided different external cues.

Subjects for the study were 81 freshmen from Ohio State University. Subjects received course credit in their beginning level psychology course for participation. Subjects signed up for the study, and names on the sign-up sheet were randomly distributed to each of the three levels of the instructional program variable. Each level of the instructional program variable was conducted during one day, but at different times.

Each of the instructional program level groups were given the same amount of time to interact with the heart instructional programs. After their program ended they were randomly distributed to testing condition. The three tests were conducted by the experimenters. Each test type group was given a maximum amount of time to respond. This was defined as the time needed for all persons to complete writing on their response sheets. Upon completion, subjects were given instructions to return in one week for the delayed testing variable.

Results and Conclusions

Data analysis has been conducted on the resulting data, using the results of the immediate testing level. The delayed testing data has since been collected, and will be analyzed and presented in a future research article by the authors. The resulting analysis of variance data is presented in Table 1, Part 1. Resulting means and standard deviations are presented in Table 1, Part 2.

Table 1, Part 1
Resulting Analysis of Variance Data

Source	Sums of Squares	Mean Squares	DF	F Ratio	Probability
Between Subjects					
Instructional Program Variable	200.07	100.03	2	4.390	0.016
Test Cue Variable	47.18	23.59	2	1.035	0.360
Interaction	319.62	79.90	4	3.507	0.011
Error	1640.66	22.78	72		

Table 1, Part 2
Resulting Means and Standard Deviations

	Free Recall Test	Visually-Cued Recall Test	Verbally-Cued Recall Test	
Visual with Label Slides Plus Audio Program	12.4 Sd=6.44	12.2 Sd=4.41	13.8 Sd=5.56	12.8
Visual Only Slide Set Plus Audio Program	7.1 Sd=3.17	12.9 Sd=3.44	8.3 Sd=3.67	9.4
Verbal Label Slides Plus Audio Program	9.7 Sd=5.39	6.2 Sd=5.33	12.7 Sd=4.5	9.5
	9.7	10.4	11.6	10.6

The resulting significant interaction between the instructional program variable and test cue variable [f,(2,72df)=3.507,p≤.01] finds support for the encoding specificity hypothesis in this study. The significant interaction is graphically displayed in Figure 7.

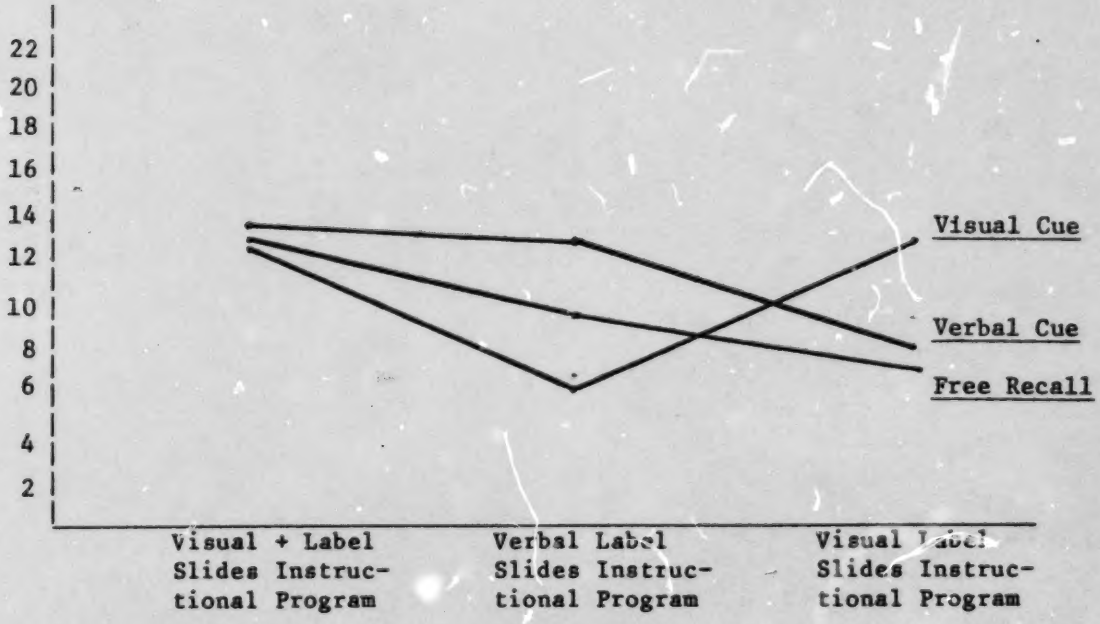

Figure 7: Significant Interaction Instruction x Test Cue.

As can be seen in Figure 7, and from the resulting pattern of simple effect means in Table 1, Part 2, test cue type and learning

context cues, had a significant effect upon the ability to perform at the time of testing. In all three instructional conditions, the subjects received the same to-be-learned target information, in this case heart part names and phase names, but in different learning contexts. Each of the instructional programs provided different cues at the time of processing to-be-learned information. If a miss-match existed between type of cue provided during learning, and type of cue provided during testing, performance on the instructional objective debilitated, even though subjects had stored in memory the to-be-learned heart part names and phase names.

These results indicate that test performance can be significantly effected, either positively or negatively, by the type of cues given at the time of testing. In this case, if the inappropriate cue is given on the test, performance is not so much a matter of what the individual has learned, but more a result of the miss-match between learning context cues--the stored memory trace--and testing context cues. Therefore, while learning may have occurred in most learners, in a behavioral sense, inappropriate test cues will result in their demonstrated performance being a function of test cue type rather than acquired intellectual skills.

Preliminary data analysis and results have indicated that the refined experimental design has resulted in the typical cross-over interaction found in traditional encoding specificity studies in the psychological area (Figures 6 and 7). More importantly, these results were achieved using a classroom group learning situation, in which academic type content was presented, and testing took place in a classroom setting. These preliminary results indicate that cues provided in the instructional setting should be isomorphic to cues provided during testing. If visuals make up an important part of instruction, similar visual cues should be provided on the test. Similarly, if instruction is essentially verbal, spatial tasks on the test may be inappropriate. While this basic principle seems like a simple rule to follow, it is amazing that with all of our sophisticated methods of visualizing content testing still remains, for the most part, verbally oriented.

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